

REMARKS

This application, as amended herein, contains claims 1 - 3, 6 - 9, and 11 - 19, and newly added claims 26-28. Claims 4, 5, 10 and 20 - 25 have been canceled.

Claim 5, 6, 11 and 21 were rejected under 35 U.S.C. 112, second paragraph. Claims 5 and 21 have been canceled. Claims 1 and 6 now both refer to a bilayer. Claim 11 has been amended to delete the term "low dielectric constant". In view of the amendments made, it is submitted that the claims are now definite within the meaning of 35 U.S.C. 112, second paragraph.

Claim 1-21 were rejected as being anticipated by Kim et al. (ALD 2002), Kim et al. (J.Vac.Sci.Tech B), or Kim et al. (J.Vac.Sci.Tech A) or Rossnagel et al. (J.Vac.Sci.Tech B). Claims 1-21 were also rejected as obvious over Chung et al. These rejections are respectfully traversed.

Claim 1 has been amended herein to recite a method for forming a bilayer of tantalum nitride and tantalum on a substrate. The method comprises depositing a first layer on the substrate by plasma enhanced atomic layer deposition of a tantalum halide precursor in the presence of a plasma containing hydrogen and nitrogen; and reducing concentration of nitrogen in the plasma to zero so that a substantially nitrogen free second layer of tantalum is formed. It is respectfully submitted that Applicants' invention, as set forth in claim 1, is not taught or suggested by the art of record.

The method of claim 1 is especially useful in forming a diffusion barrier for copper, as noted in claim 6. Advantageously, the bilayer is formed by establishing the conditions for deposition of a tantalum nitride layer, and then removing nitrogen from the plasma to obtain a nitrogen free tantalum layer.

While there is some teaching in the prior art of varying the concentration of nitrogen in a tantalum/nitrogen layer, and some teaching of the deposition of a tantalum layer, there is no teaching or suggestion of reducing the nitrogen concentration to zero to form a tantalum layer over a tantalum nitride layer. Thus, the bilayer diffusion barrier is easily and efficiently formed.

As highlighted in new claim 26 the concentration of nitrogen in the plasma is reduced to zero by switching off a source of nitrogen. Support for this new claim may be found in the specification at least at page 16, lines 6-8. Further, as noted in new claim 27, the first layer and the second layer are sequentially deposited while the substrate is in a chamber by switching off a source of nitrogen to reduce the concentration of nitrogen in the plasma to zero. This allows the bilayer to be formed in essentially a continuous process, without having to stop the overall deposition, or break vacuum.

In view of the above, it is submitted that claim 1, and newly added claims 26 and 27, as well as claim 6, are all directed to patentable subject matter.

Newly added claim 28 recites that the second layer of tantalum comprises amorphous tantalum. Support for this amendment may be found in the specification, at least at page 16, lines 15 - 28, wherein it is noted, in pertinent part, that:

This is partly because the Ta PE-ALD layer has an amorphous structure which contributes to the copper diffusion barrier properties by reducing the number of grain boundaries (Grain boundaries are the predominant copper diffusion mechanism). Further, the inherently better copper diffusion barrier property of the TaN, as opposed to that of a Ta single layer, positively contributes to the resulting diffusion barrier properties. In summary, both the amorphous PE-ALD tantalum layer and PE-ALD tantalum nitride layer positively contribute to the resulting diffusion barrier properties.

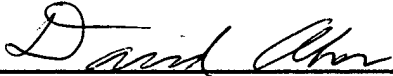
In view of the above, it is submitted that claims 1, 6 and newly added claims 26, 27 and 28 are all directed to patentable subject matter.

The remaining claims depend from claim 1. These claims include further recitation which in combination with those in claim 1, are not disclosed or suggested in the art of record. For the reasons set forth above with respect to claim 1, it is submitted that these claims are also directed to patentable subject matter.

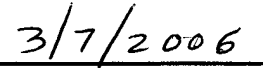
In view of the allowable nature of the subject matter of all of the claims, if the Examiner cannot issue an immediate allowance, it is respectfully requested that the undersigned be contacted to resolve any remaining issues.

Applicants respectfully request an extension of time. A check in the amount of \$1,020 for a three-month extension of time is enclosed.

Respectfully submitted,



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Date